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Is Inequality an Unavoidable By-product of Skill-Biased Technical Change? No, not necessarily!

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Abstract: This paper compares the evolution of wage inequality along three different skill groups (low-, middle- and high-skilled) across five industrialized countries (Finland, Germany, Italy, Korea and the US). Despite similar exposure to technological change, the countries exhibit significant differences in inequality trajectories, suggesting that inequality is not necessarily an unavoidable by-product of technological change.

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1. Motivation

During the past 40 years, wage inequality increased markedly in many industrialized countries. In that context, skill-biased technical change (SBTC) proved to be a quite powerful explanation (e.g. Acemoglu and Autor, 2011; Goldin and Katz, 2008). Though, it is not SBTC directly that drives inequality; it is the increasing demand for skills induced by SBTC and a lack of supply to cope with it that determines wage disparities. This has been shown in several studies for the United States (e.g. Autor et al., 2008) and various other industrialized countries (e.g. Berman et al., 1998). Since the seminal contribution of Goldin and Katz (2008), the relationship between increasing demand for high-skilled workers and increases in their supply, is often referred to as *'race between education and technology'*. It also implies that inequality is not necessarily a by-product of technological change. So far, it seems that this race has been lost by education, given that there is practically no evidence that countries sufficiently replied to the increasing demand for high skills and were able to experience decreasing inequality.[1] Against this backdrop, this paper adds to the literature in two respects: First, it empirically shows that SBTC does not necessarily imply rising inequality. Second, applying the canonical model, the paper provides new country evidence for Finland, Italy and Korea by systematically tracking educational wage gaps over time. Using the EU KLEMS dataset,[2] I compare wage inequality trajectories along three different educational groups (low-, middle- and high-skilled) for five industrialized countries Finland, Germany, Italy, Korea and the US over 36 years (1970-2005). To preview the results, Finland and Korea show diminishing inequality despite evidence of increasing demand for skills, while Germany, Italy and the US exhibit opposing trends.

[1] One notable exception is Davis (1992). However, his analysis is constrained by data limitations. For instance, given three observations, he is not able to match the supply increase in high–skilled labor in South Korea after the school reforms with the subsequent decline in inequality.

[2] The EU KLEMS dataset uses a unified approach that makes micro datasets from national sources comparable. For a complete documentation of the methodology in the computation of labor inputs in EU-KLEMS see O'Mahony and Timmer (2009).

2. Empirical approach

To systematically explore the role of labor supply in shaping inequality trends in educational wage gaps, I rely on the standard framework derived from a two-level constant elasticity of substitution production function following Goldin and Katz (2008). Assuming all skill categories (high (*H*), middle (*M*) and low (*L*)) are paid their marginal product, we can estimate the following two relationships:

$$\log\left(\frac{w_{Ht}}{w_{Mt}}\right) = \alpha_1 + \alpha_2 \text{time} + \alpha_3 \log\left(\frac{H_t}{M_t+L_t}\right) + \epsilon_{1t} \quad (1)$$

$$\log\left(\frac{w_{Mt}}{w_{Lt}}\right) = \beta_1 + \beta_2 \text{time} + \beta_3 \log\left(\frac{M_t}{L_t}\right) + \epsilon_{2t} \quad (2)$$

The skill premia $\log\left(\frac{w_{Ht}}{w_{Mt}}\right)$ and $\log\left(\frac{w_{Mt}}{w_{Lt}}\right)$ in (1) and (2) are the logs of the wage ratios of high to middle-skilled and middle- to low-skilled workers, respectively. $\log\left(\frac{H_t}{M_t+L_t}\right)$ and $\log\left(\frac{M_t}{L_t}\right)$ stand for the logs of the relative supply quantities from each group. To proxy for the (unobservable) demand shift induced by technological change, I follow the existing literature and use a linear time trend. The coefficient estimates of α_2 and β_2 can accordingly be interpreted as the annual increase in the demand for (high) skills (Acemoglu, 2002).

3. Data and methodology

Equation (1) and (2) are estimated using data from the EU KLEMS database. My analysis covers the period from 1970 to 2005 (the longest time period with complete data in the sample). The respective skill premium from (1) is constructed as the log of the ratio between the average hourly wage of a high-skilled and a medium-skilled worker.[3] The supply measure is the log of hours worked by those with tertiary education (high-skilled) divided by the sum of hours supplied in the two lower skill groups. The same procedure is applied to equation (2). Since earlier work

[3] In line with the literature, I additionally constructed composition-adjusted skill premia by indexing the relative wage to a base period, which is the average supply from 1970 to 2005 in each country (Goldin and Katz, 2008). The resulting adjusted wage measure shows a correlation of nearly one with the unadjusted measure. To achieve broader coverage, I use the unadjusted series in the empirical application.

(e.g. Acemoglu and Autor, 2011; Goldin and Katz, 2008) investigated inequality patterns using efficiency units to measure supply (instead of hours), I use data and computational files for the US from Acemoglu and Autor (2011) to investigate whether there is a difference between using efficiency units and using hours worked.[4] The coefficient estimate of labor supply derived from (1) is $\alpha_3 = -0.354$. Using their data on hours, the coefficient estimate is of the same magnitude ($\alpha_3 = -0.357$) suggesting no or little bias.

4. Comparing inequality trends

Figure 1 plots the wage gap of the high- to the medium-skilled in log points over the sample period.[5] For the US and Germany, the actual movement in the wage premium of a university degree relative to secondary education equals the findings from earlier studies (see e.g. Autor et al., 2008; Dustmann et al., 2009). Italy experienced similar increases in the post-secondary education premium. The pronounced hike in the college to non-college wage gap started in the mid-eighties right after an economic recession. Reforms were initiated in the early eighties and when the economy picked up, so did inequality. On the contrary, Finland and Korea reduced inequality in terms of the high skill premium. Scandinavian countries are typical examples for a moderate evolution of inequality, a good educational system and redistributive policies. By contrast, Korea has comprehensively reformed its educational system in the early 1980s by introducing profound education reforms. In subsequent years, these measures increased the number of tertiary educated workers. Given the coincidence of the drop in inequality with the aftermath of the policy change, it is quite likely that the rise in high-skilled labor supply outpaced the rise in high-skilled labor demand from SBTC.

[4] All files are liberally provided and perfectly documented on the homepage of David Autor. For a description of the data see Autor et al. (2008) and the data appendices therein.

[5] A wage ratio of 0.73 log points in Korea in 1980 means that a worker with a university degree receives on average 108% more wage than a worker with secondary education ($\exp(0.733) - 1 \approx 1.08$).

To examine the role of supplies more formally, I estimate equation (1). Results are presented in Table 1. Finland, Germany, Korea and the US show a positive and significant coefficient of the time trend. This complies with the demand hypothesis, that technical change is biased towards labor with tertiary education. However, Figure 1 shows that the countries exhibit significant differences in inequality trajectories: while all countries increased their supply of more educated workers,[6] it seems that only Finland and Korea managed to meet the needs of labor demand and thereby even reduced the wage gap. The coefficients of the time trends reveal that both countries show relative small annual increases in the demand for labor, about 0.9% in Finland and 0.5% in Korea. Demand growth for college educated labor was significantly larger in the US and Germany, 1.7% for the US and 1.2% for Germany. Thus, the decreasing trajectories in inequality in Finland and Korea are determined by moderate increases in labor demand for tertiary educated labor in combination with a sufficiently large supply increase. However, the case of Italy seems not to comply with the story of SBTC. Italy shows relative large increases in the premium compared to other countries in the sample, but the coefficient of the time trend is negative. This translates into a decrease in the annual demand for college educated labor by nearly 5% per annum. One possible reason might be that a shift in the structure of hours worked was lost by low-wage earners rather than by high-wage earners during that period (see also Goos et al., 2009).

Figure 2 depicts inequality trends in the lower bottom of the distribution (medium- relative to low-skilled workers). These trends should be interpreted with caution given considerable cross-country heterogeneity in the perception of educational systems below university level. Workers with identical years of education may be classified as medium-skilled in one country and low-skilled in another. However, this is of no concern from the within-country perspective. Germany,

[6] Not shown here.

Italy, and the US experienced increases in the skill premium of the medium- to the low-skilled. Italy shows the most remarkable increase in this regard. In line with Autor et al. (2008), those in the lowest skill group in the US (no high school degree) are relatively worse off since the 1980s. Since the increase in inequality coincides with the German reunion, Dustmann et al. (2009) suggest that the increasing inequality is caused by an inflow of unskilled workers which probably caused a deceleration in the decline of low-skill employment. Finland and Korea experienced increasing inequality since the mid-eighties and mid-nineties, respectively. In the case of Finland, this development became more pronounced in the years after the 1990s recession. To test for the role of relative supplies in the lower bottom of the distribution more formally, I run equation (2). However, since the late 1980s and early 1990s demand increased especially for those workers performing non-routine tasks, which do usually require less education (e.g. Autor et al., 2003; Goos et al., 2009). This polarization phenomenon of the labor market inversely affects the inequality distribution at the bottom rendering equation (2) less efficient in explaining inequality developments. Nevertheless, the signs and magnitudes of the coefficients in Table 2 for the US and Finland are as expected. Though, for Germany, Italy and Korea the simple supply and demand framework seems to be insufficient to explain inequality trends at the bottom of the distribution.

5. Conclusion

Despite increasing demand for tertiary educated workers, inequality patterns vary notably across countries. Germany, Italy and the US experienced increasing returns to a university degree, while Finland and Korea experienced decreasing returns. The latter seem to have sufficiently replied to the increasing demand for skilled labor by increasing supply more vigorously, e.g. through reforms in the education system. However, this task seems to have been easier for Finland and Korea given that the demand for college educated workers was relative small compared to

Germany or the US. These results imply that inequality is not necessarily an unavoidable outcome of technical change as long as supply of skilled labor sufficiently copes with its demand.

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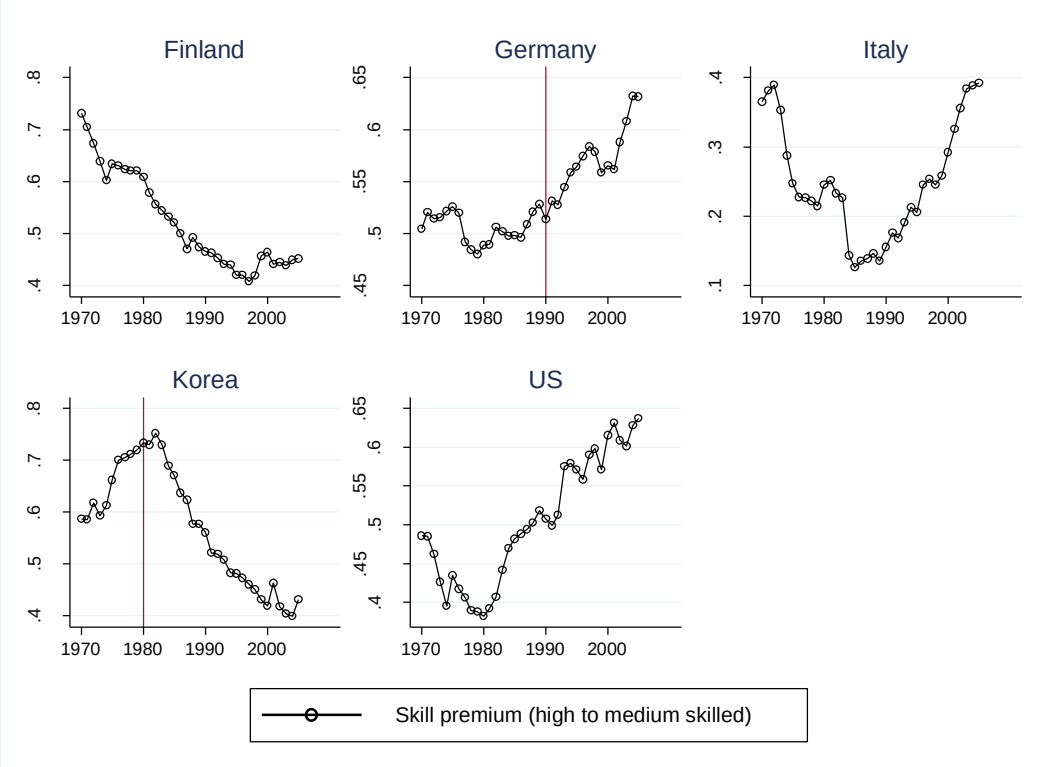

Figure 1: High- to medium-skill wage gap, 1970-2005 (log point scale)

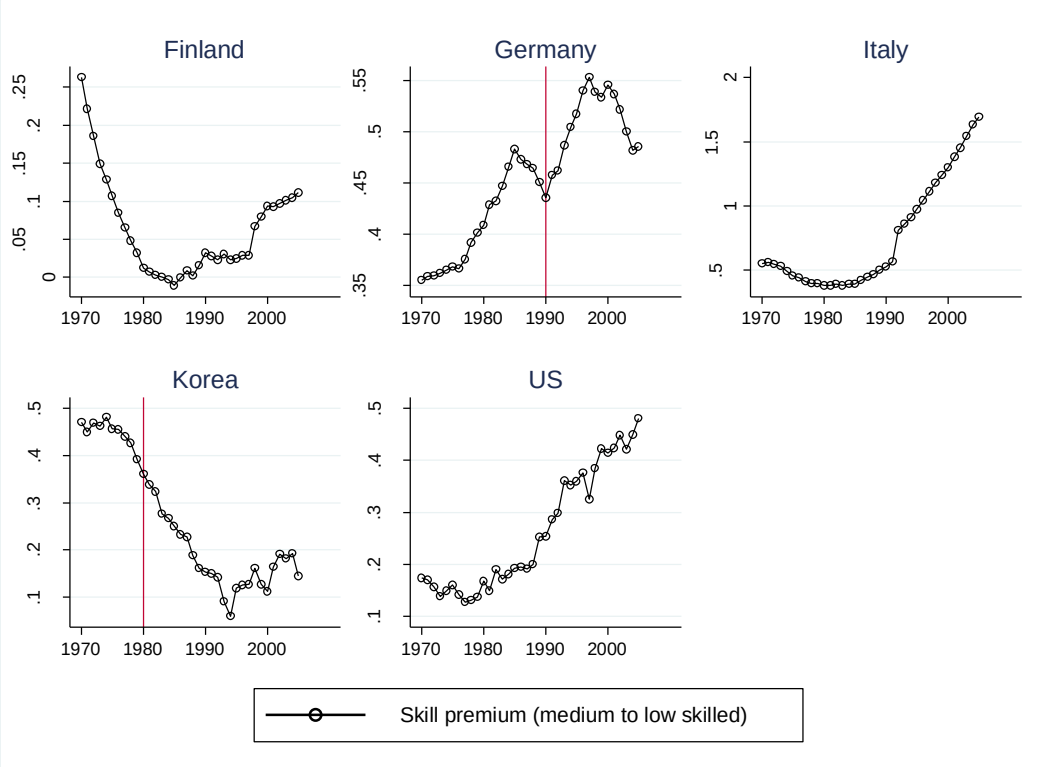

Figure 2: Medium- to low-skill wage gap, 1970-2005 (log point scale)

Table 1: High- to medium-skilled regressions

VARIABLES	(1) Finland	(2) Germany	(3) Italy	(4) Korea	(5) US
Time	0.00870***	0.0115***	-0.0477***	0.00486**	0.0172***
	(0.00125)	(0.00239)	(0.00577)	(0.00211)	(0.00207)
Relative supply	-0.384***	-0.273***	1.272***	-0.327***	-0.346***
	(0.0298)	(0.0748)	(0.138)	(0.0500)	(0.0781)
Constant	-0.0999*	-0.406*	4.566***	0.144	-0.231*
	(0.0587)	(0.243)	(0.480)	(0.0895)	(0.131)
Observations	36	36	36	36	36
R-squared	0.960	0.756	0.573	0.871	0.888

Notes: Bootstrapped s.e. in paratheses. *** (**, *) indicate statistical significance at the 1% (5%, 10%) level, respectively.

Table 2: Medium- to low-skilled regressions

VARIABLES	(1) Finland	(2) Germany	(3) Italy	(4) Korea	(5) US
Time	0.0373***	0.00287*	-0.0303	-0.0623***	0.0177***
	(0.00246)	(0.00169)	(0.0417)	(0.0156)	(0.00141)
Relative supply	-0.637***	0.156*	0.931	0.784***	-0.187***
	(0.0432)	(0.0807)	(0.587)	(0.243)	(0.0388)
Constant	-0.673***	0.295***	-1.510	1.153***	0.187***
	(0.0485)	(0.0256)	(0.988)	(0.208)	(0.0285)
Observations	36	36	36	36	36
R-squared	0.958	0.860	0.749	0.844	0.937

Notes: See Table 1.